

A Safer Gold Rush? Curbing Mercury Pollution in Artisanal and Small-Scale Gold Mining

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In Komabangou, a rural village in Niger, thousands of miners dig for gold with primitive tools.¹ They are an eclectic mix of subsistence farmers, migrant laborers from neighboring West African countries, underemployed public sector workers, and university students—men, women, and children. Some were born here; others have traveled far in search of work. All livelihoods in Komabangou revolve around the small-scale retrieval of gold—from those doing the digging to the people feeding them, supplying their equipment, and transporting them from site to site.

The miners engage in a centuries-old process of gold extraction that involves the intensive use of mercury. “Mercury makes this entire system function,” says Gavin Hilson, an environmental policy researcher at the University of Surrey in the United Kingdom. Hilson has studied the environmental and social impacts of artisanal and small-scale gold mining (ASGM) in Kombangou and other locales.

The scope is much bigger than this one village in sub-Saharan Africa. The use of mercury to mine for gold has become a key part of the survival strategy for millions of the world’s poor as gold prices have spiked in recent decades. Estimates of the number of ASGM workers vary widely; one 2018 calculation puts the figure at 16 million miners in more than 70 countries, mainly in Asia, Africa, and South America.² They work mostly in what is known as the informal economy, meaning they are neither regulated nor protected by their governments.

ASGM contributes an estimated 17–20% of the world’s gold.² It is a modern-day gold rush driven largely by poverty, with ASGM workers representing some of society’s most vulnerable individuals. As many as 5 million women and children are estimated to work in the sector.³

ASGM is also the single biggest source of mercury pollution in the world, by one estimate contributing almost one-third of global mercury air emissions.⁴ “It is a huge source of mercury and a huge health problem. But it is also a huge economic opportunity for the rural poor in places where there are not a lot of other opportunities,” says Susan Keane, a senior environmental analyst with the Natural Resources Defense Council and co-lead of the ASGM area of the United Nations Environment Programme’s Global Mercury Partnership.

Under the Minamata Convention on Mercury—an international treaty to reduce global mercury use—participating countries must draw up National Action Plans to reduce and eliminate sources of mercury within their borders.⁵ For some countries, that includes ASGM. Reducing mercury use in ASGM throughout the developing world will be a challenge, according to Keane and other health and policy experts. Yet, if done right, there could be positive impacts on both environmental human health and global poverty.

A Global Pollutant

Doctors and scientists have known for centuries about the health hazards of mercury. European hatmakers, for instance, began experiencing neurological symptoms such as tremors and delirium as early as the 17th century after they began dipping rabbit pelts into vats of mercuric nitrate to stiffen the hairs.⁶ Mercury poisoning, at the time, was viewed as an occupational hazard.

Then an historic incident in the mid-twentieth century brought attention to mercury as a public health issue.

In 1956, investigators determined that high levels of methylmercury pollution in Japan’s Minamata Bay from industrial dumping was causing severe physical deformities and neurological problems in thousands of people, including babies whose mothers ate fish out of the bay.⁷ For nearly 40 years after Minamata, “it was believed that you had to be exposed to very high doses of mercury in order to suffer any adverse effects,” says Philippe Grandjean, an epidemiologist at the University of Southern Denmark and adjunct professor of environmental health at Harvard University.

Researchers have since proven that prevailing wisdom wrong. Grandjean’s own work in the Faroe Islands, an archipelago about halfway between Norway and Iceland, was among the first to associate methylmercury exposure with subtle decrements in brain function at doses believed to be safe.⁸ What’s more, there were no major polluting industries in the Faroe Islands that could account for the methylmercury contamination in the whale meat that was the Faroese villagers’ main source of exposure.

Researchers began to study how mercury moves through the environment. Elemental mercury emitted into the air can travel virtually worldwide, eventually coming to rest on the soil or water. Once it lands—or if it is released directly into soil or water through industrial activity—it can be converted by microorganisms into methylmercury, which bioaccumulates in aquatic organisms and works its way up the ocean food chain.⁹ That means that mercury emitted in one part of the globe has the potential to poison wildlife and humans thousands of miles away.

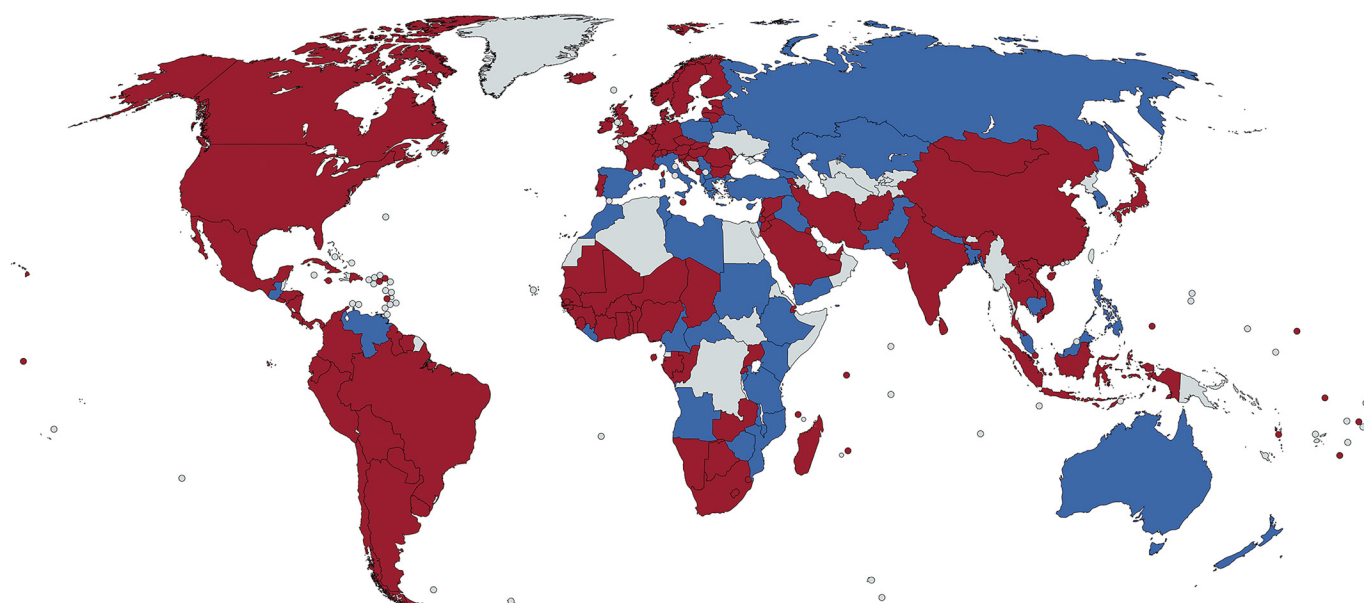
“The realization that [mercury] was polluting the global seafood supply initiated international talks about what to do about it,” says Grandjean. Mercury pollution could no longer be viewed as a local or regional problem that any one country alone could solve.¹⁰

This realization culminated in the adoption of the 2013 Minamata Convention, an international agreement in which Parties pledge to control or eliminate mercury emissions and releases from various industrial sources (including coal-fired power plants and waste incineration) and to phase the toxic metal out of certain products (such as batteries, lightbulbs, cosmetics, and pesticides).⁵ As of November 2019, there were a total of 114 Parties to the Convention, whose rules went into effect in 2017.¹¹

Unlike previous international environmental treaties that focused on groups of pollutants—such as the 2001 Stockholm Convention to restrict the use of persistent organic pollutants or the 1997 Kyoto Protocol to reduce emissions of six different greenhouse gases—the Minamata Convention focuses on a single so-called sunset chemical. These are chemicals deemed so detrimental to human health and the environment that the international community believes “the sun should set on their use for good,” Grandjean explains.

Mercury Use in ASGM

When negotiators met in Minamata in 2013, coal-fired power plants were on everyone’s radar as a major source of mercury emissions. Yet most delegates were surprised to learn that ASGM is actually the single largest source of mercury pollution in the world, says Keane. And mercury pollution from ASGM continues



Parties

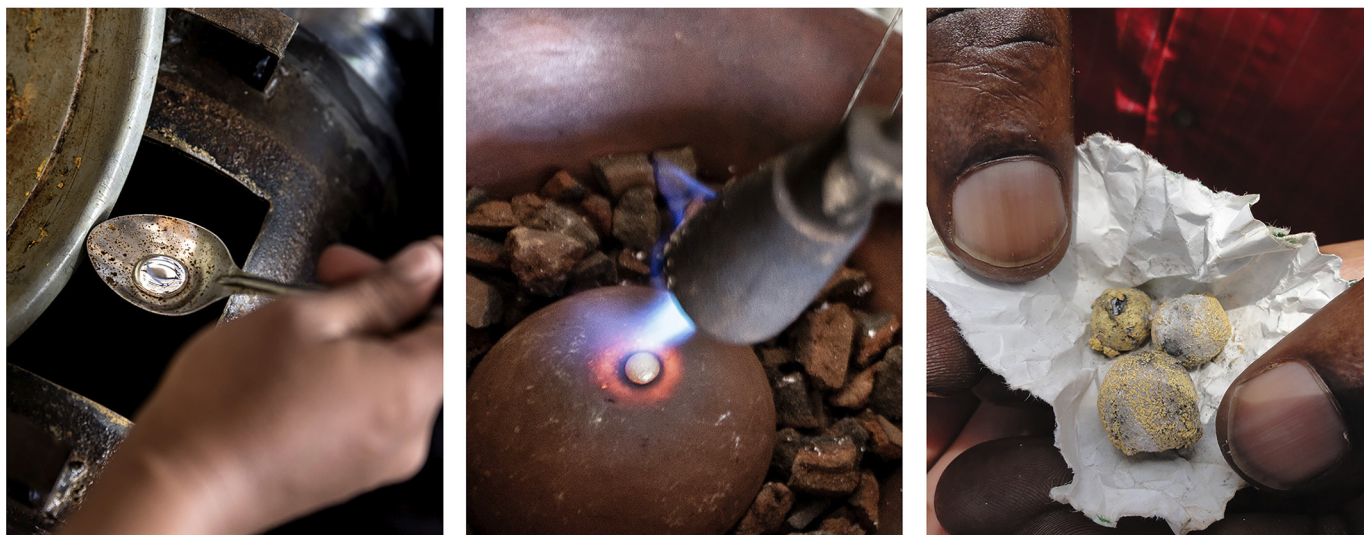
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| Afghanistan | Antigua and Barbuda | Argentina | Armenia | Austria |
| Belgium | Benin | Bolivia | Botswana | Brazil |
| Bulgaria | Burkina Faso* | Canada | Chad | Chile |
| China | Colombia | Comoros | Congo, Republic of the* | Costa Rica |
| Côte d'Ivoire | Croatia | Cuba | Czechia | Denmark |
| Djibouti | Dominican Republic | Ecuador* | El Salvador | Estonia |
| Eswatini* | European Union | Finland | France | Gabon* |
| Gambia | Germany | Ghana* | Guinea* | Guinea-Bissau |
| Guyana* | Honduras* | Hungary | Iceland | India |
| Indonesia* | Iran | Ireland | Jamaica | Japan |
| Jordan | Kiribati | Kuwait | Lao PDR* | Latvia |
| Lebanon | Lesotho | Liechtenstein | Lithuania | Luxembourg |
| Madagascar* | Mali* | Malta | Marshall Islands | Mauritania |
| Mauritius | Mexico | Moldova | Monaco | Mongolia* |
| Montenegro | Namibia | Netherlands | Nicaragua | Niger* |
| Nigeria* | Norway | Palau | Palestine | Panama |
| Paraguay* | Peru* | Portugal | Romania | Rwanda* |
| Saint Kitts & Nevis | Saint Lucia | Samoa | Sao Tome & Principe | Saudi Arabia |
| Senegal* | Seychelles | Sierra Leone* | Singapore | Slovakia |
| Slovenia | South Africa | Sri Lanka | Suriname* | Sweden |
| Switzerland | Syrian Arab Republic | Thailand | Togo | Tonga |
| Tuvalu | Uganda* | United Arab Emirates | United Kingdom | United States |
| Uruguay | Vanuatu | Vietnam | Zambia* | |

Signatories

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|-----------|-------------|-----------------|---------------------------|-------------|
| Albania | Angola* | Australia | Bangladesh | Belarus |
| Burundi* | Cambodia | Cameroon | Central African Republic* | Cyprus |
| Ethiopia | Georgia | Greece | Guatemala | Iraq |
| Israel | Italy | Kenya* | South Korea | Liberia |
| Libya | Malawi | Malaysia | Morocco | Mozambique* |
| Nepal | New Zealand | North Macedonia | Pakistan | Philippines |
| Poland | Russia | Serbia | Spain | Sudan |
| Tanzania* | Tunisia | Turkey | Venezuela | Yemen |
| Zimbabwe* | | | | |

* Countries with National Action Plans to address ASGM

As of November 2019, 113 countries and the European Union have become parties to the Minamata Convention, meaning they consent to be bound by the obligations of the Convention. An additional 41 countries have signed the Convention, meaning they intend to become Parties eventually. Thirty-one countries are implementing National Action Plans that address ASGM emissions. (Another four countries—Democratic Republic of the Congo, Eritrea, Kyrgyzstan, and Myanmar—also are addressing ASGM emissions even though they are neither Parties nor Signatories.) Map: © MapChart.net; country listings: UNEP (2019).¹¹



In the process of whole ore amalgamation, gold-bearing rock is crushed, then combined with elemental mercury, which separates the gold particles from the other minerals present. The resulting balls of mercury–gold amalgam are heated to vaporize the mercury. The vaporization leaves behind a porous lump of semi-pure “sponge gold” that will later be refined into pure gold. Images, left to right: © Kemal Jufri/Panos Pictures; © Kemal Jufri/Panos Pictures; © Artisanal Gold Council.

to rise, linked closely with widening poverty and stagnating economic development.⁴

Mercury is cheap and readily available to miners. It is used in varying amounts and for varying purposes in ASGM, depending on factors such as regional geology, cultural preferences, and scale of operation.³ One of the most hazardous and widely used practices is a technique called whole ore amalgamation.

In this process, rocks and ore are crushed by hand to the consistency of coarse sand, then added to motorized mills to mix for several hours with liquid mercury. The mercury extracts gold particles from the crushed ore by forming an amalgam (an alloy) of mercury and gold. The amalgam forms dense, solid balls, typically 40–80% mercury by mass,³ that are separated easily by hand from the crushed sand.

To recover the gold from the amalgam, miners heat the balls to vaporize the mercury—often indoors, with poor ventilation. In some locations, miners may take their amalgam to a centralized processing center in a village, where this mercury distillation step will be performed for a fee.³

In some cases, the vaporized mercury is recovered, says Justin Chalker, a synthetic chemist at Flinders University in South Australia, who studies ASGM techniques. However, most mercury in ASGM is lost directly to the environment at this stage. “Even when it is recovered,” Chalker says, “it is only used for a few more gold extractions because it becomes oxidized and not as effective at capturing gold.”

The distillation process can result in extraordinarily high concentrations of mercury vapor, Chalker says. Typically, no measures are taken to prevent mercury inhalation, which can result in brain and nerve damage, kidney damage, and several other health problems for miners and those living around processing facilities.¹² Beyond the inhalation hazard, vaporized mercury can also deposit in surface waters and soils, where it is converted to methylmercury, providing a different exposure route.

Meanwhile, the leftover tailings—crushed ore, water, and mercury—that remain after amalgam balls are plucked from the mixture are often released directly into waterways. In some cases, the tailings are processed further in large tanks with a cyanide solution to help extract more unrecovered gold before their release into the environment.³

Minamata Convention First Steps

There is no specific timeline under the Minamata Convention for reducing the use of mercury in ASGM. Countries that judge themselves to have “more than insignificant” ASGM activity within their borders—a descriptor that is not actually defined in the Convention¹³—must notify the Secretariat, at which point they have three years to develop their National Action Plans. More than 70 countries are believed to have some ASGM, says Henrik Selin, an associate professor of international relations at Boston University and an expert observer for the Minamata Convention on Mercury Effectiveness Evaluation Committee.

Even prior to the Minamata Convention, many countries had banned ASGM outright or at least the use of mercury in the industry. These efforts have proved largely ineffective, due in part to the rising cost of gold.¹⁴ “What we’ve seen instead is an explosion in the past twenty years of ASGM activity in the informal sector, in which miners are operating largely outside the law,” Selik explains.

In some cases, countries are trying to transition miners into other lines of work. But the Minamata Convention encourages countries with ASGM activity to consider legalizing or formalizing the sector.¹⁵ Formalization, in theory, would put governments and the international community in a position to better monitor the environmental impacts of ASGM more effectively while providing miners with “security of tenure,” or legitimacy in the eyes of the law, “so they can flourish as regular businesses that do not have to fear being prosecuted,” explains Hilson.

Science and policy experts theorize that access to financing will be a major barrier to transitioning miners off mercury to cleaner technologies.¹⁶ Formalization is a precondition to being able to procure many sources of funding, explains Keane. “If you want a loan from the bank [for instance, to buy new equipment], you need to have a bank account, you need to be a formal entity,” she says.

Yet, bringing ASGM into the formal economy comes with challenges. Moves by governments to regulate the informal sector could lead to unrest, especially in countries where there’s deep distrust of government motives, according to Hilson. Doing it successfully will require more than just making it easier for small-scale miners to get permits or buy equipment.



The Minamata Convention encourages countries to consider legalizing or formalizing ASGM. Formalization has many potential benefits, including better oversight of worker and environmental conditions, more job security for miners, and increased likelihood of the industry developing in a sustainable fashion. In this photo, Jason Gaber of Mt. Baker Mining and Metals demonstrates how to use a shaker table for a group of government officials and mining representatives seeking to formalize ASGM in Kenya. Image: © Mt. Baker Mining and Metals.

“The effectiveness of formalization hinges on a government’s ability to simultaneously address related development issues, such as youth unemployment and support for agriculture,” he says. Selin adds that some developing countries may lack the financial and human resources—or the political will—to tackle such a complex issue, rife with environmental and societal implications.

Strategies for Change

The Convention also urges the adoption of technologies that could reduce the use and emissions of mercury in ASGM and replace whole ore amalgamation. When properly implemented, these technologies and methods would not only reduce mercury releases and emissions but could also make the gold extraction process more efficient and, thus, lucrative. “The only way to change the practice of the artisanal mining space is to ensure miners can see obvious and short-term economic benefits,” says Chalker.

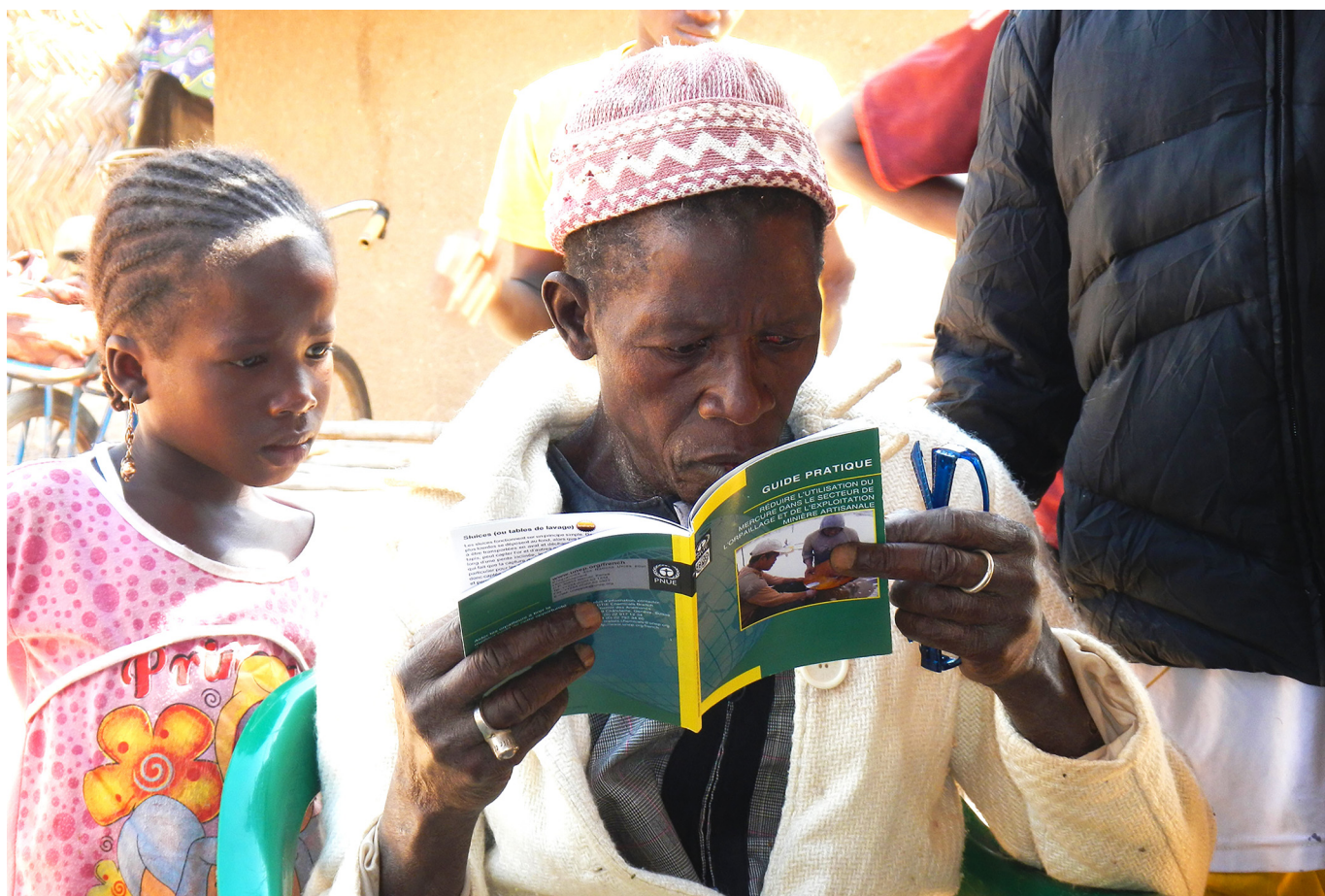
Retorts or condenser units, for instance, could be added to help recover liquid mercury for reuse in the mercury distillation process while also lowering human exposures to mercury vapor in mining communities. Efficient and low-cost milling equipment, sluices, shaker tables, and other gravitational separation techniques could help miners concentrate gold and increase yield while using less mercury.³ Whereas artisanal mining methods using mercury typically yield 30–40% of recoverable gold from ore,¹⁷ gravimetric equipment provides two to three times that much, says Jason Gaber, co-owner and cofounder of Mt. Baker Mining and Metals. This U.S.-based equipment manufacturer has partnered

with nongovernmental organizations (NGOs) and worked directly to introduce shaker tables throughout Africa.

Small-scale capacity-building projects offer a useful start, according to Kenneth Davis, programme officer for the Chemicals and Waste Branch of the United Nations Environment Programme (UNEP). For instance, in 2015 and 2016, UNEP partnered with Indonesian NGOs to set up a training center to teach miners in East Java how to use mercury-free techniques.¹⁸ In Burkina Faso and Senegal, the Canadian-based nonprofit Artisanal Gold Council has organized a pilot program called the 2 Kilogram Model. This program demonstrates how organized cooperatives of small-scale miners could pay back the cost of new gravimetric equipment and training (valued at \$70,000–200,000) with the cost of roughly 2 kg of gold, an amount they could expect to extract in 40 working days using improved techniques.¹⁷

Yet key challenges remain in convincing miners of the harms of mercury—and that there are better ways. In the Madre de Dios mining district in the Peruvian Amazon, for instance, mercury amalgamation has been a popular method for extracting precious metals since Spanish colonialists introduced it in the 1500s.¹⁹ There are strong, positive cultural associations with mercury, explains Ruth Goldstein, an anthropologist at the University of California, Irvine, who works in ASGM communities in Madre de Dios. “There are notions of virility tied to mercury. People simply do not believe that something so beautiful could be dangerous or poisonous,” she says.

Even where miners understand the health and environmental impacts of methylmercury, thinking about the future is not a luxury that typically poverty-stricken workers enjoy, Hilson says.



Groups such as the United Nations Environment Programme and the Artisanal Gold Council are teaching miners how to incorporate relatively inexpensive technologies and simple methods into their work so they can continue making a living—perhaps even a better living—even as they reduce mercury exposures. Image: © Artisanal Gold Council.

“These are people looking to survive today. If you are a poor farmer relying on that two grams of gold at the end of the day to buy food or put your kid in school, you are not likely to experiment with a shaker table or new gravitational technique,” he says.

Reducing mercury outputs from ASGM is a process that will take years, and one that may look very different between a large country such as Indonesia (with an estimated 250,000 ASGM operators²) and a small one such as Guyana (with an estimated 28,000 miners²), says Keane. Every three years, Minamata Parties are required to report on their progress in meeting their objectives. Adherence to National Action Plans is one way the Convention will track progress, though it is not yet clear how effectiveness will be judged. For instance, the authors of a 2018 review published in *Environmental Health Perspectives* concluded that all populations worldwide are exposed to some amount of mercury, but that data from many regions are limited, hindering evidence-based decision making.⁹

Effectiveness evaluations are expected to be a major topic of discussion at the third meeting of the Conference of the Parties to the Minamata Convention on Mercury, which will take place in November 2019 in Geneva, Switzerland. If countries fail to meet their objectives in the timeframe outlined, the international community may step in to monitor activities and enforce deadlines, according to Keane. That does not mean shaming countries who do not comply, she says: “The focus should be on identifying assistance mechanisms that can be employed to support countries to do a better job.”

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